Application of Jet Trimming in Boosted Higgs Search*

Wenhan Zhu
Department of Physics, Princeton University, Princeton, NJ 08544

Abstract

We present the study of the WH and ZH search with the Higgs Boson decayed to $b\bar{b}$ at the Large Hadron Collider. The Higgs Boson and the Vector Boson are required to be boosted, and the Higgs Boson is reconstructed with Jet Trimming Technique. The statistical significance for $30fb^{-1}$ data is 4.5 σ, which is comparable to the previous result [6].

1 Introduction

The Higgs Boson search is the most important search at the Large Hadron Collider (LHC), because it is an essential part of the standard-model electroweak symmetry breaking. Current electroweak fits, together with the LEP and Tevatron exclusion limit, favour a light Higgs boson one with mass around 120 GeV [1] [2]. It is a challenging task for the discovery of Higgs Boson at this mass region [3] [4].

The Mass Dropping and Filtering method introduced in [6] makes the Higgs Boson production channel associated with a vector boson very promising. In this channel, the Higgs Boson will decay hadronically into two b-tagged jet with the vector boson decay leptonically. The dominant background for this process is VV,Vj and $t\bar{t}$. We will employ a similar kinematic selection to [6], but we will reconstruct the Higgs Boson using the jet trimming technique [5].

2 Jet Trimming

Jet Trimming [5] is a designated procedure for removing the ISR/MI/Pileup from the FSR. The intrinsic idea is that ISR/MI/Pileup will be much softer than the FSR, therefore, we will form a fat jet using a larger cone and then recluster the fat jet with a smaller cone and throw away the softer subjets.

We will make some change to the original algorithm described in [5] for the jet substructure of the boosted Higgs Boson. First, we will find the two b-tagged

*Talk presented by Wenhan Zhu at Pheno 2011, Madison, Wisconsin, May 2011.

jets by clustering the jet constituents of the fat jet. Also, the Higgs jet, different from a QCD jet, is a dipole itself, so we expect to have more radiation between the two b quarks. Therefore, we will use a dynamical $f_{\rm cut}$, which is proportional to the distance between the subjet and the fat jet.

The jet trimming algorithm proceeds as follows:

- Cluster all the final state particles with Fastjet 2.4.2 [8],antik_T algorithm with a cone size 1.2.
- Cluster the particles in the hardest jet with a smaller cone size 0.3 with antik_T algorithm to find out the hardest two subjets, and we will require each of the two subjets to be b tagged. We assume a 60% tagging efficiency and 2% of mistagging efficiency.
- Cluster the remaining particles with an even smaller cone size 0.2 with k_T algorithm to form the subjets.
- If $p_T^i > f_{\rm cut} p_T \Delta R$ the subjet is kept else it is trimmed, p_T is the p_T of the fat jet and ΔR is the distance between the subjet and the fat jet. The $f_{\rm cut}$ is chosen to be 0.03 in this analysis.
- Now we have the Higgs Candidate. We will require the Higgs Candidate p_T larger than 200 GeV and η less than 2.5.

3 Results

The events are generated by Pythia 6.403 [7], fully showered and hadronized. The underlying event is incorporated by Pythia "DW" tune. For this analysis, signal samples of WH, ZH were generated, as well as $WW, ZW, ZZ, Z+$jet, $W+$ jet, $t\bar{t}$ to study backgrounds.

There are three search channels in this analysis and the channel specific cuts are very similar to [6]:

- Leptonic channel: two opposite sign lepton (e or μ) with $p_T > 30$ GeV and $|\eta| < 2.5$, with an invariant mass between 80 and 100 GeV.
- Missing E_T channel: Missing Transverse momentum$>$ 200GeV.
- Semi-leptonic Channel: Missing transverse momentum$>$ 30GeV plus a lepton (e or μ) with $p_T >$ 30GeV. Veto event if there is jet with $p_T > 30$ GeV and $|\eta| < 3.0$.
- all channel: no more lepton with $p_T > 30$ GeV and $|\eta| < 2.5$ except to reconstruct the vector boson, no more b-tagged jets with $p_T > 30$ and $|\eta| < 2.5$.

The mass spectrum of the Higgs Candidate with m_H =115 GeV is shown in Fig 1 for the three sub-channel and combined channel. The number of both signal and background for Higgs Mass between 112-128 GeV for $30 fb^{-1}$ data

Channel	Signal	V+Jet	$t\bar{t}$	VV	S/B	S/$\sqrt{B}$
Leptonic	5.4	10.0	0.032	0.53	0.51	1.66
Missing E_t	24.3	65.6	12.9	3.4	0.3	2.7
Semi-leptonic	30.6	35.0	49.9	1.6	0.35	3.3
Total	60.3	110.60	62.8	6.5	0.34	4.5

Table 1: Signal and Background for a 115 GeV SM Higgs Boson for 30 fb^{-1}.

is shown in Table 1, the significance is 4.5 σ(8.2σ for 100 fb^{-1}). The result is comparable to [6] and offer an alternative strategy for search for boosted Higgs.

4 Conclusion and Outlook

Here we have applied jet trimming technique to the boosted Higgs Boson search for a low mass(115 GeV) SM Higgs Boson. The statistical significance for $30 fb^{-1}$ data is 4.5 σ, which is comparable to the previous result [6]. This could be considered as an alternative search strategy for the high-p_T WH,ZH channel at the LHC.

5 Acknowledgement

The author would like to acknowledge useful discussions with Valerie Halyo, David Krohn, Gavin Salam and Lian-tao Wang.

References

[1] M. W. Grunewald, J. Phys. Conf. Ser. **110**, 042008 (2008). [arXiv:0709.3744 [hep-ph]].

[2] T. Aaltonen *et al.* [CDF and D0 Collaborations], Phys. Rev. Lett. **104**, 061802 (2010) [arXiv:1001.4162 [hep-ex]].

[3] G. Aad *et al.* [The ATLAS Collaboration], [arXiv:0901.0512 [hep-ex]].

[4] G. L. Bayatian *et al.* [CMS Collaboration], J. Phys. G **G34**, 995-1579 (2007).

[5] D. Krohn, J. Thaler and L. T. Wang, JHEP **1002**, 084 (2010) [arXiv:0912.1342 [hep-ph]].

[6] J. M. Butterworth, A. R. Davison, M. Rubin and G. P. Salam, Phys. Rev. Lett. **100**, 242001 (2008) [arXiv:0802.2470 [hep-ph]].

[7] T. Sjostrand, S. Mrenna and P. Z. Skands, JHEP **0605**, 026 (2006) [arXiv:hep-ph/0603175].

[8] M. Cacciari and G. P. Salam, Phys. Lett. B **641**, 57 (2006) [arXiv:hep-ph/0512210].

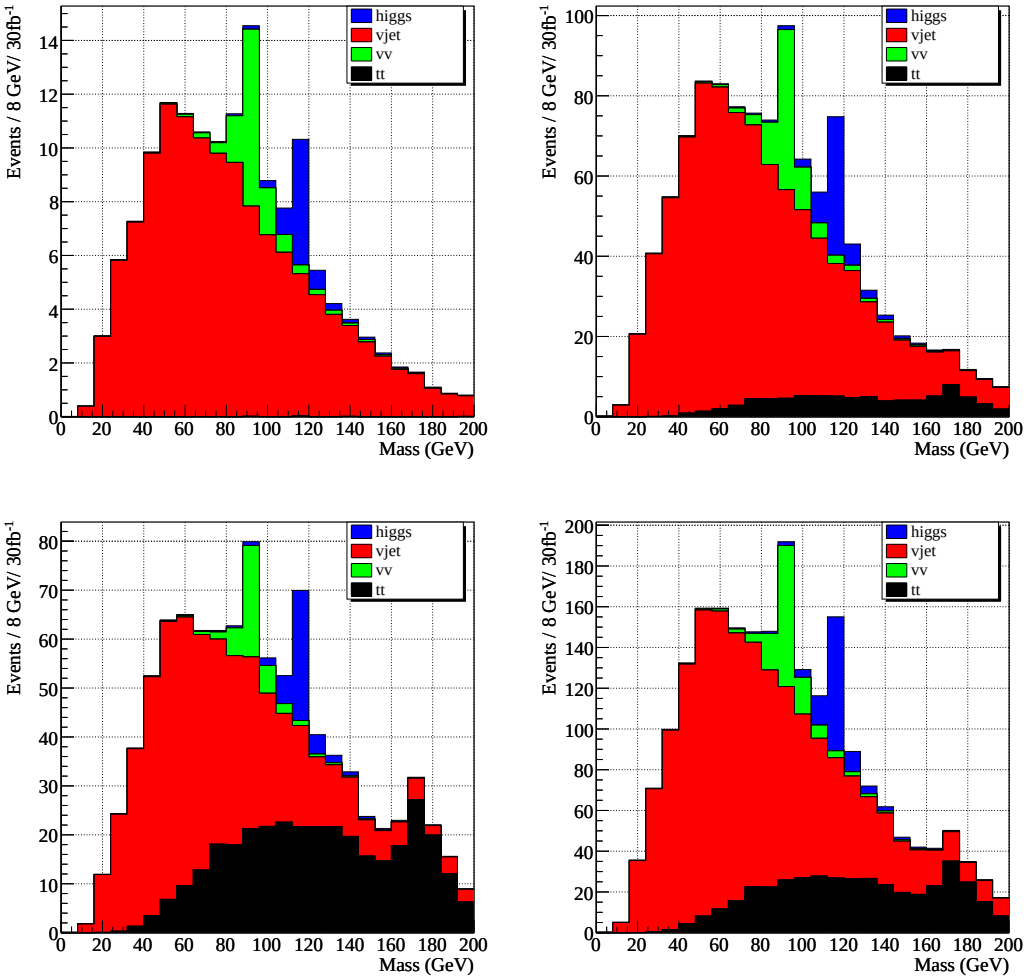

Figure 1: The Signal and Background for a 115 GeV SM Higgs Boson for 30 fb^{-1}. On the top, the left plot is or leptonic channel and the right plot is for missing Et channel. On the bottom, the left plot is for semi-leptonic channel and the right plot is the total signal and background for all the channel.